U.S.D.A. FOREST SERVICE RESEARCH PAPER PNW-62

SEASONAL HEIGHT GROWTH OF UPPER-SLOPE CONIFERS

CARROLL B. WILLIAMS, Jr.

PACIFIC NORTHWEST FOREST & RANGE EXPERIMENT STATION

U.S. Department of Agriculture · Forest Service

Portland, Oregon *1968*

* * * *

The author, formerly research forester at the Forestry Sciences Laboratory, Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Corvallis, Oregon, is now Insect Ecologist, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Berkeley, California.

* * * *

INTRODUCTION

There is little knowledge of seasonal distribution of height growth of some of the principal coniferous species of the middle to high elevations of the Cascade Range in the Pacific Northwest. This paper describes observations made during 1963 and 1964 on height growth of subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), noble fir (*A. procera* Rehd.), Pacific silver fir (*A. amabilis* (Dougl.) Forbes), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), western white pine (*Pinus monticola* Dougl.), lodgepole pine (*P. contorta* Dougl.), western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), mountain hemlock (*T. mertensiana* (Bong.) Carr.), and western redcedar (*Thuja plicata* Donn).

Measurements were made on saplings growing in association on two naturally stocked areas. All the above species were present on an old burn near Government Camp, Mount Hood National Forest. Only Pacific silver fir, Douglas-fir, noble fir, western hemlock, and western white pine saplings were present on the second study area--a clearcut (unit 9) within the Lava Lakes cutting block near the Santiam-Clear Lake Junction in the central Oregon Cascades. The two areas are similar in aspect (N-NE) and elevation (3,900 to 4,000 feet). The Government Camp area has poor-quality soil that developed on a mudflow approximately 1,700 years old. The Lava Lakes soil developed on several feet of volcanic ash that was deposited about 1,500 years ago. The forests at Lava Lakes are taller and more productive than at Government Camp. With the exception of Pacific silver fir, the saplings on each area were 10 to 15 years old and were post-logging regeneration. Pacific silver fir saplings were advanced regeneration that had survived logging and burning and many were 40 to 50 years old.

METHODS

The first 10 to 13 relatively isolated trees of each species, 5 to 6 feet in height, were selected for observations in each area. All selections were made as soon as snow conditions permitted access to the area in 1963. Selected trees were numbered by tags and the base of each year's terminal bud was marked with paint or with an insect pin to serve as a reference point for weekly elongation measurements. Dates of bud burst, cessation of height growth, and weekly height growth measurements in centimeters from the marked base to the tip of the elongating shoot were recorded for each tree.

At the end of each growing season, the average height growth of each species was plotted in centimeters and in percent of total by area and by date. Variations among species in (1) start of height growth (bud bursting), (2) average length of growing periods in days, (3) total amount of height growth, and (4) average time required to complete 50, 90, and 100 percent of growth were tested by analyses of variance. Differences among species were tested for significance by area and year. Western white pine saplings at Government Camp were heavily cankered by blister rust and were not used in the study.

RESULTS

Generally, the differences among the tree species at each area for the length of time to bud burst, completion of 50, 90, and 100 percent of total growth, length of growing season, and total amount of growth were significant at the 1-percent level (table 1).

The pines commenced height growth earlier and tended to have slightly longer growing seasons than any other species except western redcedar. The buds of the pines had already started to elongate by the time snow conditions permitted access to study areas during both growing seasons. Bud bursting did not occur on the other conifers until 3 to 4 weeks later. By that time, the pines had completed up to 30 percent of their seasonal height growth.

In 1964, height growth started 2 to 4 weeks later than in 1963 (table 1), due mainly to heavy snow accumulations and cool spring weather which retarded snow melting (U.S. Weather Bureau 1964,[1/] pp. 62, 82, 102, 122). Height growth generally terminated later in 1964 than in 1963. The growing season generally was longer at Lava Lakes than at Government Camp.

At Government Camp, the 1964 growing season was shorter than the 1963 season for all species, although it was about the same both years for western hemlock and Douglas-fir. The true firs and mountain hemlock had a relatively short growing season, particularly in 1964. Western redcedar had the longest growing seasons of all for both years (fig. 1). Lodgepole pine, Douglas-fir, and western redcedar grew the most in height, whereas the true firs grew the least. Douglas-fir and western hemlock trees grew a little more in 1964 and 1963 despite the cooler spring and shorter growing season of 1964.

At Lava Lakes, the 1964 growing season was shorter than the 1963 season for all species except western hemlock. Western white pine, noble fir, and western hemlock had longer growing seasons than the other conifers and western hemlock was the last species to stop growing (fig. 2). Western white pine and noble fir grew the most in height during both seasons, whereas western hemlock grew the least during 1963 and Douglas-fir grew the least in 1964 (fig. 2). Western hemlock trees grew more in 1964 than in 1963. The true firs grew as well or better than their associates on the volcanic ash soil at Lava Lakes in contrast to their relative poor performances on the poor soil at Government Camp.

Evidently, conifers growing on the same area and, therefore, under apparently equivalent environmental conditions:

1. Begin height growth at different times,
2. Have seasonal height-growth periods of different lengths,
3. Seem to be affected differently by annual fluctuations of climate.

DISCUSSION

Results show definite individuality of bud bursting and seasonal height-growth patterns among the conifers studied. Total height growth and lengths of growing season of the species varied between years and places. That such differences are under partial genetic control has been well documented with

---

[1/] Names and dates in parentheses refer to Literature Cited, p. 7.

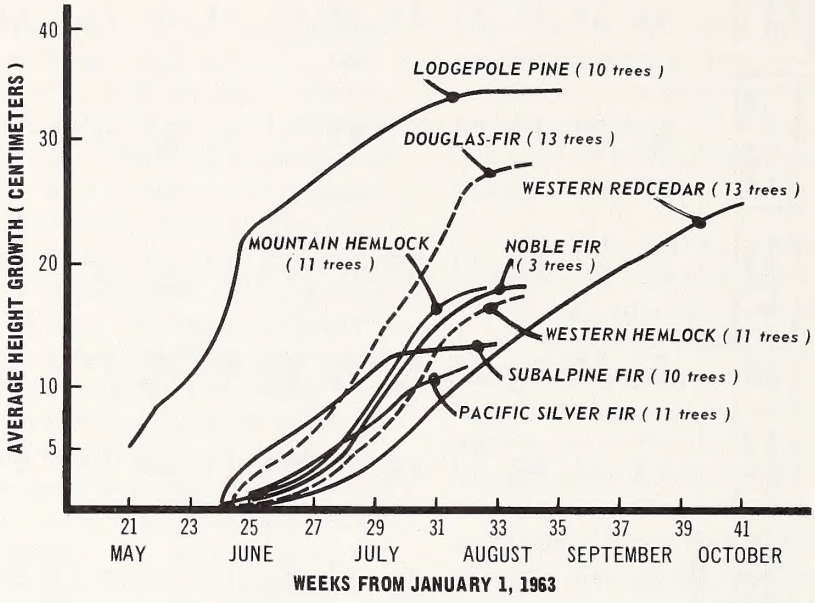
Table 1.--*Results of analyses of variance tests on the average days from January 1 to bud burst, completion of 50, 90, and 100 percent of growth, length of growing season, and total amount of growth of upper-slope conifers at Lava Lakes and Government Camp in Oregon during 1963 and 1964*

Item	Location	Year	Tree species									Significance level[1/]
			Pacific silver fir	Douglas-fir	Western hemlock	Western redcedar	Mountain hemlock	Subalpine fir	Noble fir	Lodgepole pine	Western white pine	
			Number of days									
From Jan. 1 to bud burst	Government Camp	1963	168	170	169	163	166	163	169	(2/)	(2/)	**
		1964	190	190	189	185	191	192	(3/)	--	--	NS
	Lava Lakes	1963	162	169	171	--	--	--	165	(2/)	(2/)	NS
		1964	186	191	180	--	--	--	184	--	--	**
From Jan. 1 to 50-percent completion of growth	Government Camp	1963	191	198	206	228	198	178	194	164	--	**
		1964	204	212	219	224	211	189	(3/)	187	--	**
	Lava Lakes	1963	189	195	205	--	--	--	201	--	168	**
		1964	204	204	216	--	--	--	208	--	188	**
From Jan. 1 to 90-percent completion of growth	Government Camp	1963	209	219	221	263	212	200	216	199	--	**
		1964	219	234	238	256	224	215	(3/)	211	--	**
	Lava Lakes	1963	210	216	224	--	--	--	220	--	206	**
		1964	218	223	236	--	--	--	227	--	209	**
From Jan. 1 to completion of growth	Government Camp	1963	222	234	234	283	229	216	231	233	--	**
		1964	229	250	251	273	232	223	(3/)	238	--	**
	Lava Lakes	1963	229	234	239	--	--	--	240	--	241	**
		1964	231	238	252	--	--	--	244	--	236	**
Length of growing season	Government Camp	1963	54	64	65	120	63	53	62	(2/)	(2/)	**
		1964	39	60	62	88	42	31	(3/)	--	--	**
	Lava Lakes	1963	67	65	68	--	--	--	74	(2/)	(2/)	*
		1964	45	51	71	--	--	--	59	--	--	**
			Centimeters									
Total amount of height growth	Government Camp	1963	11.5	27.5	17.1	23.9	17.5	13.0	17.7	33.5	--	**
		1964	9.1	31.6	17.9	18.5	16.2	9.2	(3/)	30.5	--	**
	Lava Lakes	1963	32.8	27.6	23.4	--	--	--	41.2	--	40.3	**
		1964	21.7	17.4	25.8	--	--	--	29.1	--	34.8	**

1/ NS = not significant; ** = significant at 1-percent level.

2/ Bud burst had already occurred on these species by the time the areas became accessible in the spring.

3/ The terminal buds formed in 1963 on the noble fir study trees at Government Camp were nipped by grouse.



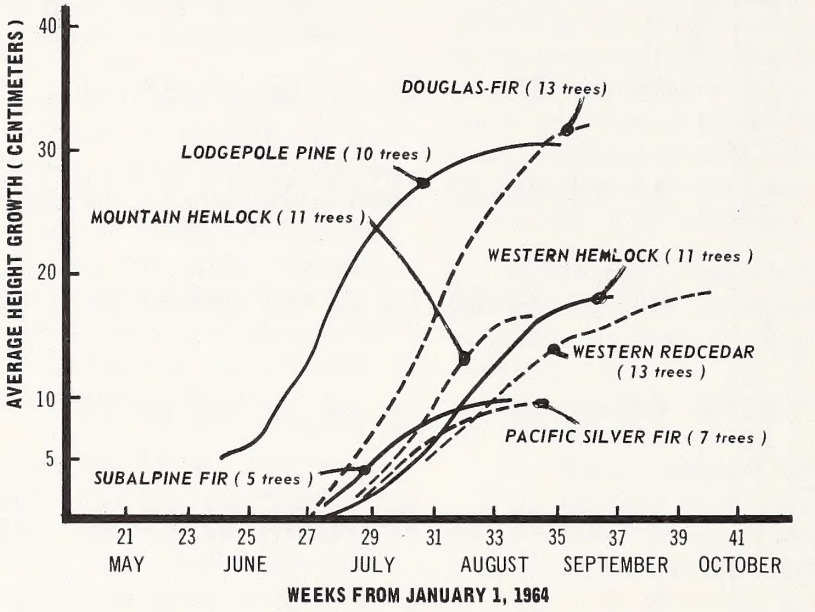
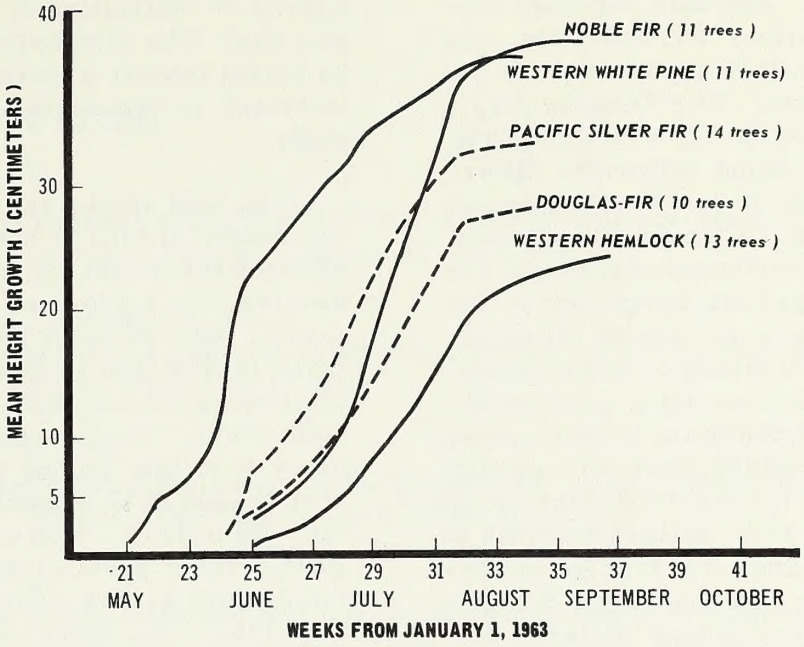


Figure 1.--Average cumulative height growth of coniferous tree species near Government Camp, Oreg., in 1963 and 1964. Differences among species were significant at the 1-percent level.



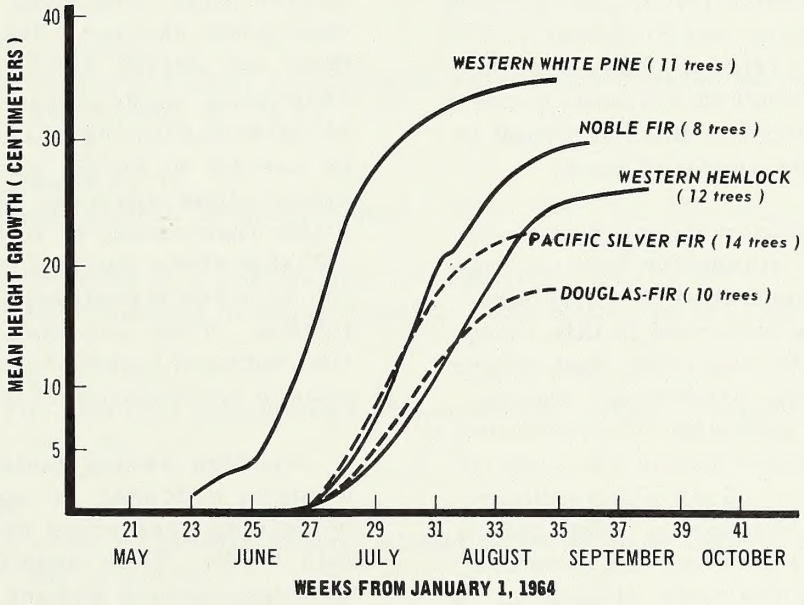


Figure 2.--Average cumulative height growth of five coniferous tree species at Lava Lakes, Oreg. Height growth among species was significantly different at the 1-percent level.

significant literature reviewed by Kozlowski (1964). The data reported here for Pacific silver fir, noble fir, and mountain hemlock apparently are the first available. For Douglas-fir, Irgens-Moller (1957) and Ching and Bever (1960) found important differences in time of bud break between seed sources. Silen (1962), working in a narrow environmental range, estimated the genetic component of the bud bursting trait among several Douglas-fir clones to be about 95 percent of the total variance. In general, seasonal distribution of leader growth of western hemlock, western redcedar, and Douglas-fir observed in this study followed the same pattern reported by Walters and Soos (1963) at lower elevations in British Columbia. Similar seasonal leader growth patterns for western hemlock have also been described by Godman (1953) and Gregory (1957) in Alaska and Buckland (1956) on Vancouver Island. The latter two studies also showed seasonal growth distribution for Douglas-fir which is similar to that reported here.

Some of the variation in bud bursting and shoot elongation between tree species is based on type of terminal bud. Species observed in this study, except western redcedar, had winter buds containing preformed shoots. Much of the potential of preformed shoots is formed during the year of bud formation. Such shoots begin elongation in the spring using carbohydrate reserves from the previous season, and internode elongation is often complete before the leaves are fully grown. Due to the dependence on carbohydrate reserves, shoot growth often shows closer correlation with weather of the year of bud formation rather than the year of shoot elongation (Kozlowski and Keller 1966). However, weather during the period of shoot elongation does influence the degree of realization of shoot growth potential. The effect of current weather on height (shoot) growth was well illustrated in the second year of this study.

The cool spring and shorter growing season of 1964 at both study areas affected the height growths of several species with preformed buds. On both areas, only western hemlock grew more in 1964 than in 1963. Its lengths of growing seasons were similar for both years. Douglas-fir trees grew more in height during the shorter 1964 season at Government Camp than they did in 1963. However, at Lava Lakes, their growing season and total height growth were less in 1964 than 1963. All other species with preformed shoots in their buds, particularly the true firs, grew less during the shorter 1964 season than they did during 1963. These observations suggest that at times length of current growing season is related to amount of height growth in some upper-slope species. The findings differ from those by Walters and Soos (1963) in their study of conifers growing at lower elevations in British Columbia. They reported no correlation between length of current growing season and quantity of leader growth.

Species having scale leaves like western redcedar do not form buds containing preformed shoots (Laubenfels 1953). They usually have long growing seasons and use considerable current photosynthate for shoot growth (Kozlowski and Keller 1966). Consequently, their height growth is usually well correlated with current weather. This study showed the height growth of western redcedar was related to current growing season as expected.

LITERATURE CITED

Buckland, D. C.
1956. Terminal shoot growth of four western conifers for a single growing season. Forest. Chron. 32: 397-399.

Ching, K. K., and Bever, D.
1960. Provenance study of Douglas-fir in the Pacific Northwest Region. Silvae Genet. 9: 1-32.

Godman, R. M.
1953. Seasonal distribution of leader growth. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 19, 2 pp.

Gregory, R. A.
1957. A comparison between leader growth of western conifers in Alaska and Vancouver Island. U.S. Forest Serv. Alaska Forest Res. Center Tech. Note 36, 2 pp.

Irgens-Moller, Helge.
1957. Ecotypic response to temperature and photoperiod in Douglas-fir. Forest Sci. 3: 79-83.

Kozlowski, Theodore T.
1964. Shoot growth in woody plants. Bot. Rev. 30: 335-392.

Kozlowski, Theodore T., and Keller, Theodor.
1966. Food relations of woody plants. Bot. Rev. 32: 293-382.

Laubenfels, D. J., de.
1953. The external morphology of coniferous leaves. Phytomorphology 3: 1-20.

Silen, Roy R.
1962. A study of genetic control of bud bursting in Douglas-fir. J. Forest. 60: 472-475.

U.S. Weather Bureau.
1964. Climatological data, Oregon. Vol. 70, Nos. 4, 5, 6, 7.

Walters, J., and Soos, J.
1963. Shoot growth patterns of some British Columbia conifers. Forest Sci. 9: 73-85.

Williams, Carroll B., Jr.
1968. Seasonal height growth of upper-slope conifers. U.S.D.A. Forest Serv. Res. Paper PNW-62, 7 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

Time of bud burst and seasonal distribution of height growth were studied for 2 consecutive years on eight coniferous species growing in association on two upper-slope areas in the Oregon Cascades. At each area, significant variations between species and years generally were found for initiation of bud bursting, length of growing season, and 50-, 90-, and 100-percent completion of growth. Total height growth seemed to be related to length of current growing season, particularly for the true firs and mountain hemlock.

Williams, Carroll B., Jr.
1968. Seasonal height growth of upper-slope conifers. U.S.D.A. Forest Serv. Res. Paper PNW-62, 7 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

Time of bud burst and seasonal distribution of height growth were studied for 2 consecutive years on eight coniferous species growing in association on two upper-slope areas in the Oregon Cascades. At each area, significant variations between species and years generally were found for initiation of bud bursting, length of growing season, and 50-, 90-, and 100-percent completion of growth. Total height growth seemed to be related to length of current growing season, particularly for the true firs and mountain hemlock.

Williams, Carroll B., Jr.
1968. Seasonal height growth of upper-slope conifers. U.S.D.A. Forest Serv. Res. Paper PNW-62, 7 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

Time of bud burst and seasonal distribution of height growth were studied for 2 consecutive years on eight coniferous species growing in association on two upper-slope areas in the Oregon Cascades. At each area, significant variations between species and years generally were found for initiation of bud bursting, length of growing season, and 50-, 90-, and 100-percent completion of growth. Total height growth seemed to be related to length of current growing season, particularly for the true firs and mountain hemlock.

Williams, Carroll B., Jr.
1968. Seasonal height growth of upper-slope conifers. U.S.D.A. Forest Serv. Res. Paper PNW-62, 7 pp., illus. Pacific Northwest Forest & Range Experiment Station, Portland, Oregon.

Time of bud burst and seasonal distribution of height growth were studied for 2 consecutive years on eight coniferous species growing in association on two upper-slope areas in the Oregon Cascades. At each area, significant variations between species and years generally were found for initiation of bud bursting, length of growing season, and 50-, 90-, and 100-percent completion of growth. Total height growth seemed to be related to length of current growing season, particularly for the true firs and mountain hemlock.

Headquarters for the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is in Portland, Oregon. The area of research encompasses Alaska, Washington, and Oregon, with some projects including California, the Western States, or the Nation. Project headquarters are at:

College, Alaska
Juneau, Alaska
Seattle, Washington
Olympia, Washington
Wenatchee, Washington
Portland, Oregon
Bend, Oregon
La Grande, Oregon
Corvallis, Oregon
Roseburg, Oregon

The FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives – as directed by Congress – to provide increasingly greater service to a growing Nation.